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ABSTRACT

The interrelationships between aptitude test performance and certain demographic-cultural variables were investigated, as well as the relationship between these variables and the aptitude test factor content. Five test batteries were administered to groups of approximately 1,900 subjects each. Multiple regression analyses indicated that there were significant interaction effects for six of the selected tests. The relationships between the cultural variables combined and each aptitude test were significant for all tests. Significant net relationships of race, educational level, and geographic area were found with a majority of tests, although wide differences were found among aptitude tests in their sensitivity to demographic-cultural influences. Race appeared to be related to tests in most factor areas, with its highest relationship in the mechanical area, whereas education, which had the lowest relationships with the mechanical area, had the highest relationships with verbal, numerical, and reasoning factors. No discernible trend was noted for geographic area. (Author/BH)

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AFHRL-TR-70-15

AIR FORCE HUMAN RESOURCES LABORATORY

DEMOGRAPHIC DIFFERENCES IN APTITUDE TEST PERFORMANCE

By

Nancy Guinn
Ernest C. Tupes
William E. Alley

PERSONNEL RESEARCH DIVISION
Lackland Air Force Base, Texas

May 1970

AIR FORCE SYSTEMS COMMAND

BROOKS AIR FORCE BASE, TEXAS

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FOREWORD

This report presents comparative data on the aptitude test performance of personnel differing in demographic, educational, and ethnic backgrounds.

The research was accomplished under Project 7719, Research and Development on Reliability, Adaptability, and Effectiveness of Air Force Personnel; Task 771902, Research on Prediction and Assessment of Adaptability of Low Ability Airmen to Air Force Life.

This report has been reviewed and is approved.

John G. Dailey, Colonel, USAF
Commander

ABSTRACT

The joint and independent relationships between aptitude test performance and certain demographic-cultural variables were investigated as well as the relationships between these variables and the aptitude test factor content. Five test batteries were administered to groups of approximately 1,900 subjects each. Multiple linear regression analyses indicated that there were significant interaction effects for six of the selected tests. The relationship between the cultural variables combined and each aptitude test was significant for all tests. Significant net relationships of race, educational level, and geographical area were found with a majority of tests although wide differences were found among aptitude tests in their sensitivity to demographic-cultural influences. With regard to factor content, race appeared to be related to tests in most factor areas, with its highest relationship in the mechanical area. Education had the highest relationships with verbal, numerical, and reasoning factors and the lowest relationships with the mechanical area. No discernible trend with regard to factor content was noted for geographical area.

SUMMARY

Guinn, Nancy, Tupes, E.C. & Alley, W.E. *Demographic differences in aptitude test performance.* AFHRL-TR-70-15. Lackland AFB, Tex.: Personnel Research Division, Air Force Human Resources Laboratory, May 1970.

Problem

The effectiveness of the Air Force career assignment system relies to a large extent on the aptitude testing program. For over two decades, aptitude testing of non-prior-service airmen has permitted the Air Force to match its talent resources with existing manpower requirements. The diversity of the airman population, however, creates a special problem in aptitude assessment. To insure that interests and abilities are accurately and impartially evaluated, a selection test must be applicable to a wide range of demographic, educational, and ethnic subgroups. Otherwise, individual talents that may be of benefit to the service remain untapped. In an effort to improve existing techniques and to explore new methodologies, the present study focused on the problem of assessing personnel from differing cultural backgrounds. Its purpose was to investigate the role of selected demographic variables in aptitude test performance. Such information will provide a basis for determining whether observed subgroup differences in test performance reflect actual differences in ability or whether the differences are a function of tests that may be culturally biased for or against certain groups.

Approach

Experimental aptitude batteries, sampling a wide variety of specific abilities, were administered to five groups of approximately 1,900 basic airmen each. Demographic and cultural information which was thought to be related to test performance was gathered in a biographical questionnaire given in conjunction with the experimental batteries. The combined and independent relationships between the cultural variables and aptitude test performance were investigated in a series of multiple linear regression analyses. Operational implications were discussed in terms of differential selection ratios that would occur when various tests are used as screening devices.

Results

The relationships between the cultural variables combined and each aptitude test were significant for all tests although the magnitude of the relationships for several of the tests was quite small. Tests showing the strongest relationships with the demographic variables appeared to be those containing factors most commonly thought of as components of general intelligence, such as verbal, numerical, and reasoning abilities. The weakest relationships were found with those tests containing memory, spatial, and psychomotor factors. Significant net relationships of race, educational level, and geographical area were found with a majority of tests although wide differences were noted among aptitude tests in their sensitivity to demographic influences.

Race appeared to be related to test performance in most factor areas. In a comparison of mean performances, Negroes as a group scored lower than whites on all tests although the size of these differences varied with the type of aptitude being measured. In general, the tests in which racial differences were most evident were those which required specific knowledge of the subject matter gained prior to the test situation (i.e., mechanical and verbal tests). This is in contrast to the non-verbal, spatial, and psychomotor tests that are situationally defined and, consequently, less dependent on background experiences. In these tests, racial differences were much less pronounced.

Education showed the highest relationships with tests containing verbal, numerical, and reasoning factors and the lowest relationships with the mechanical tests. Performance trends indicated that those enlistees who had attained higher educational levels performed better than those with less education. Only in the mechanical tests were reversals noted. There appeared to be no distinct trends in the relationships between geographical area and test factor content. On the whole, the differences between areas of the country were uniformly low as compared with racial and educational differences. However, for the majority of tests in which area was a significant factor, mean test performance of enlistees from the South was lower than that of enlistees from the North, Midwest, or West.

Analyses to determine whether there was any significant interaction among the cultural variables in predicting aptitude test performance revealed interaction effects for six of the tests.

Conclusions

It was concluded on the basis of these analyses that there are wide differences between aptitude tests in their sensitivity to demographic and cultural influences. There appears to be considerable interaction between the type (factor content) of the test and the demographic variables with which its scores are most highly related. However, it should be noted that while the results of this study indicate that there are significant relationships of the cultural-demographic variables with aptitude test performance, the question of whether or not the lower-than-average test scores of any one subgroup are indicative of equally low performance on later criteria of success has not been explored. Aptitude tests are, designed to give an indication of an individual's potential for performing in a subsequent criterion or performance situation. An aptitude test cannot be said to be biased or discriminatory unless the subgroup actually performs higher (or lower) in the criterion or performance situation than would be expected on the basis of its test scores. To answer this question adequately, further analyses of the interrelationships between test scores, demographic variables, and some measure of criterion performance should be accomplished to determine whether each aptitude test actually discriminates against certain subgroups or whether subgroup differences in test scores are reflections of true differences in the underlying aptitude.

The significant interaction effects seem to indicate that, in a few cases, higher order interactions of the cultural variables increase prediction over and above the contribution of the primary variables themselves, although the relationships between the primary variables may not be as complex and interrelated as previously anticipated.

This summary was prepared by William E. Alley, Personnel Systems Branch, Personnel Research Division, Air Force Human Resources Laboratory.

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DEMOGRAPHIC DIFFERENCES IN APTITUDE TEST PERFORMANCE

I. INTRODUCTION

Since 1948, aptitude testing has been an integral part of the Air Force selection and assignment system. The primary purpose of the military testing program is to provide information about specific talents and abilities in an effort to match the aptitudes of incoming personnel with Air Force manpower requirements.

Concurrent with the operational testing program, a significant amount of research is directed toward the improvement of existing techniques and the exploration of new methodologies. Recently, there has been an increasing interest in exploring the effectiveness of aptitude tests when used to measure specific abilities of personnel differing in cultural, educational, and ethnic backgrounds. More specifically, attention has centered on the relative performance of certain subgroups on a number of aptitude measures in order to determine whether differences in test performance exist, and if so, to what extent. It is often pointed out that aptitude tests are not pure measures of aptitudes and that the non-aptitude factors entering into aptitude test scores may carry so much weight that a minority group may receive below-average scores on the test when their "real" aptitude is at the average or above-average level. Therefore, this type of research is necessary to provide a basis for determining whether or not observed differences in test performance reflect actual differences in ability across subgroups or whether these differences are a function of tests that may be culturally weighted, or biased, for or against certain subgroups.

Although a considerable amount of research has been reported concerning differences in test performance as a function of demographic-cultural variables, these analyses have primarily focused on tests of general intelligence (Campbell, 1964, 1965; Dreger & Miller, 1960; Shuey, 1966). In general, studies in the aptitude area have included only a few of the many aptitudes for which tests have been developed (Lucas, 1953; Gordon, 1955; Portenfield, 1964). Moreover, the majority of these studies have emphasized the effect of one demographic-cultural variable on test performance rather than the joint effects of several different cultural variables operating together. For example, the extent to which observed aptitude test score differences associated with race are a function of similar differences on two or more other cultural variables has not been investigated.

This report describes one of several studies undertaken to obtain further information and answers to the question of subgroup differences in test performance and the role of aptitude tests in the selection and screening of applicants. The study was specifically designed to (*a*) investigate both the joint and independent relationships between performance on a wide variety of aptitude tests and a number of demographic-cultural variables (specifically race, geographical area of residence, educational level, economic status, and city size); (*b*) determine the differential effects of the demographic-cultural variables on specific factor content contained in the aptitude battery; and (*c*) illustrate the effect of cutoff scores on subgroup selection when certain aptitude tests are used to screen applicants.

II. METHOD

Subjects

The subjects were five groups of approximately 1,900 non-prior-service basic airmen in their first week of basic training. This sample was probably quite representative of all young men in the 18 to 20 year age group except for some restriction on educational level and general intelligence. As a function of Air Force enlistment policy, the proportion of enlistees with less than a high school education is lower than that found in the general population as is the proportion of men who are college graduates. Similarly, enlistment policy excludes many of those at the lower end of the intelligence scale, and self-selection excludes a large proportion of the brighter individuals.

Demographic-Cultural Variables

Five demographic-cultural variables which were believed to be potentially related to differences in aptitude test performance and relatively independent of each other were selected for study: race, educational level, geographical area of permanent residence, economic status, and city size. A short biographical questionnaire was devised to obtain this information on each subject. Table 1 indicates

the distributions for each of the demographic-cultural variables for the five experimental groups. Examination of this table indicates that all groups were fairly similar with respect to their distribution on these variables. Preliminary analyses revealed only minimal relationships between test performance and the variables economic status and city size. Therefore, these two variables were deleted from further analysis.

Aptitude Tests

Fifty-six paper-and-pencil tests designed for group administration were selected to insure a fairly complete coverage of aptitude types and factors. Most of the tests were shortened to 10 to 15 items so that a greater number of tests could be taken by each subject in the time available. Each revised test was administered on a preliminary basis to groups of 350 to 400 subjects to establish time limits and to obtain reliability estimates. Detailed analyses were performed with all of the aptitude tests; however, to simplify presentation and interpretation of results, 25 of the 56 aptitude tests were chosen as representative of the more important aptitude types and factors.[1] Table 2 contains a list of the 25 selected tests along with their factor content and reliability estimates. Table 6 in the appendix contains this information for the complete list of tests.

Procedure

Since it was not feasible to administer the complete battery of 56 aptitude tests to any one group of subjects, the total number of tests was divided into five test batteries. Each of the five groups of subjects was administered one of the test batteries along with the biographical questionnaire.

[1] Similar analyses for the aptitude tests not included in this report are available to qualified users upon request to AFHRL (PAPF), Lackland AFB, TX 78236.

Table 1. Frequency Distributions for Demographic Variables by Experimental Group

Demographic Variable	N for Experimental Group				
	1	2	3	4	5
Race					
1. Negro	139	158	195	159	237
2. White	1,674	1,704	1,672	1,687	1,725
City Size					
1. Under 10,000 population	658	714	748	718	785
2. 10,000 - 100,000 population	547	561	530	559	545
3. Over 100,000 population	608	587	589	569	632
Economic Status					
1. Income under $6,000	758	738	731	688	840
2. Income over $6,000	1,055	1,124	1,136	1,158	1,122
Geographical Area of Permanent Residence					
1. ME, NH, Conn, Mass, RI, Vt, NY, NJ, Pa	410	459	417	453	436
2. Va, Md, Del, WVa, DC, Ky, Tenn, NC, SC, Miss, Ala, Ga, Fla, La, Ark	532	497	523	460	571
3. Ohio, Mich, Ind, Ill, Wisc, Mo, Iowa, Minn	477	498	516	423	505
4. ND, SD, Nebr, Kan, Colo, Wyo, Ariz, Cal, Nev, Idaho, Mont, Ore, Wash, Utah, Tex, Okla, NM	394	408	411	510	450
Educational Level					
1. High school non-graduate	74	70	83	63	134
2. High school graduate	1,071	995	977	971	1,060
3. College (1 year or more)	668	797	807	812	768
Total N	1,813	1,862	1,867	1,846	1,962

Table 2. Reliability Estimates and Factor Content[a] of Selected Aptitude Tests

Aptitude Test	Test-Retest Reliability	Factor Content
Answer Sheet Marking	.84	Aiming, Perceptual Speed, Carefulness
Arithmetic Reasoning	.88	Numerical, Deduction, Verbal Comprehension
Arithmetic Speeded Operations	.93	Numerical
Block Counting	.90	Spatial, Spatial Orientation, Perceptual Speed
Data Interpretation	.56	Numerical, Deduction
Electrical Information	.88	Mechanical Experience, Verbal Comprehension
Electrical Maze	.80	Perceptual Speed, Planning, Spatial
Figure Analogies	.86	Planning, Deduction, Visualization
General Mechanics	.82	Mechanical Experience
Hidden Figures	.81	Gestalt Flexibility, Spatial, Perceptual Speed
Large Tapping	.85	Aiming, Tapping
Mechanical Principles	.86	Mechanical Experience, Visualization, Spatial
Mutilated Words	.69	Gestalt Perception, Spatial
Number Series	.84	Numerical, Deduction, Verbal Comprehension
Number-Word	.78	Associative Memory
Object Completion	.84	Gestalt Perception
Pattern Comprehension	.77	Visualization, Deduction, Perceptual Speed
Pattern Detail	.67	Associative Memory
Pursuit Aiming II	.76	Aiming
Rotated Blocks	.79	Spatial, Spatial Orientation
Table Reading	.81	Numerical, Perceptual Speed, Spatial
Tools	.91	Mechanical Experience
Tool Functions	.89	Mechanical Experience, Perceptual Speed
Verbal Analogies	.88	Verbal Comprehension, Deduction
Word Knowledge	.87	Verbal Comprehension

[a] Factor content of aptitude tests based on analyses by French (1951) and authors' estimates of factor content for test areas not included in French analysis.

III. RESULTS AND DISCUSSION

Analysis of the data is divided into two phases. The first phase describes the joint and independent relationships between performance on the various aptitude tests and the demographic-cultural variables of race, area, and educational level. In addition, the relationships between the cultural variables and specific factor content are explored. In the second phase, emphasis is placed on the use of these aptitude tests in personnel selection showing the percentages of each subgroup which would be selected (or rejected) if certain cutoff scores for each aptitude test were used to screen applicants.

Relationships Between Test Performance and Demographic Variables

Multiple linear regression as outlined by Bottenberg and Ward (1963) was the principal method of analysis for the initial phase of the study. Tables 3 and 4 summarize the results of the analyses which are presented in detail in Tables 7 through 12 in the appendix. The first regression analysis for each aptitude test determined whether there were any significant second order interaction effects among the demographic variables on test performance. Such an analysis would provide answers to questions such as "Do Negro and white

Table 3. Significance of Contribution of First Order Interactions to Prediction of Subtest Performance
(Summary of Regression Analysis Results)

Criterion Subtest	Significance Level of Interacting Variables		
	Race x Education	Race x Area	Area x Education
Arithmetic Reasoning	.01	ns	.01
Figure Analogies	.05	.05	ns
Large Tapping	ns	ns	.01
Object Completion	ns	.01	ns
Rotated Blocks	ns	ns	.05
Tools	ns	ns	.05

high school graduates and non-graduates differ in aptitude test performance depending on whether they live in the North or the South?" or "Are the differences in aptitude performance between educational levels in the various parts of the United States the same for Negroes as for whites?" As indicated in Table 7 in the appendix, no significant interactions were found at this level, so it may be assumed that the relationships between the tests and any one of the primary cultural variables did not vary as a function of the other two primary cultural variables.

The next regression analysis was to determine whether or not any significant first order interaction effects existed. For example, "Are the differences between high school and college graduates the same for both Negroes and whites?" or "Is the difference in test performance between high school graduates and non-graduates the same in the West as in the East?" As shown in Table 9 in the appendix, significant interaction effects were found for six of the aptitude tests (Arithmetic Reasoning, Figure Analogies, Large Tapping, Object Completion, Rotated Blocks, and Tools). Further regression analyses were performed with these six tests to determine which of the three possible first order interactions were significant (see Table 3). The interactions are depicted in Figures 1 through 3 in a series of bivariate plots of subgroups means. For two of the aptitude tests, Arithmetic Reasoning and Figure Analogies, a significant race and education interaction was found. The [illegible] Its can be interpreted to mean that the differences in test performance between Negroes and whites varied depending upon educational level. As shown in Figure 1, the differential effects of education for the two races can be readily noted. At the high school non-graduate level, the performance of the Negro and white subgroups was quite similar although this finding should be interpreted with caution. The Negro non-graduate sample was so small that performance estimates for this group may be somewhat unstable. Progressively greater differences in test performance between the races were evident at the high school and college levels. This trend generally substantiates the findings of previous research in which Negro and white differences have been found to become more distinct as educational level increases (Shuey, 1966). The primary factors responsible for this disparate performance may be the differences in quality of education received and socioeconomic level. Those schools located in poor neighborhoods may suffer from lack of facilities and a broad, enriched curriculum; in addition, economic factors may affect the probability that a child will have access to books and opportunities for early learning experiences which may directly or indirectly affect his later test performance

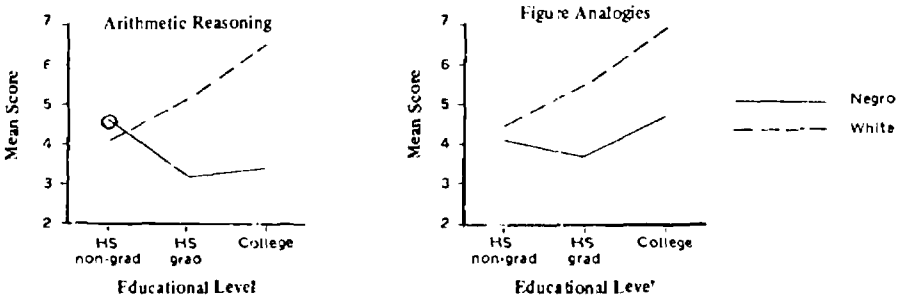

Fig. 1. Interaction effects of race and educational level on subtest performance. *(Circled plot indicates mean based on less than 10 cases.)*

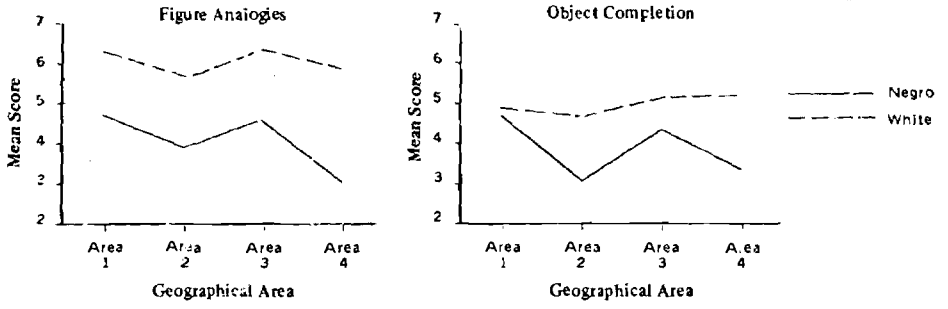

Fig. 2. Interaction effects of race and geographical area on subtest performance.

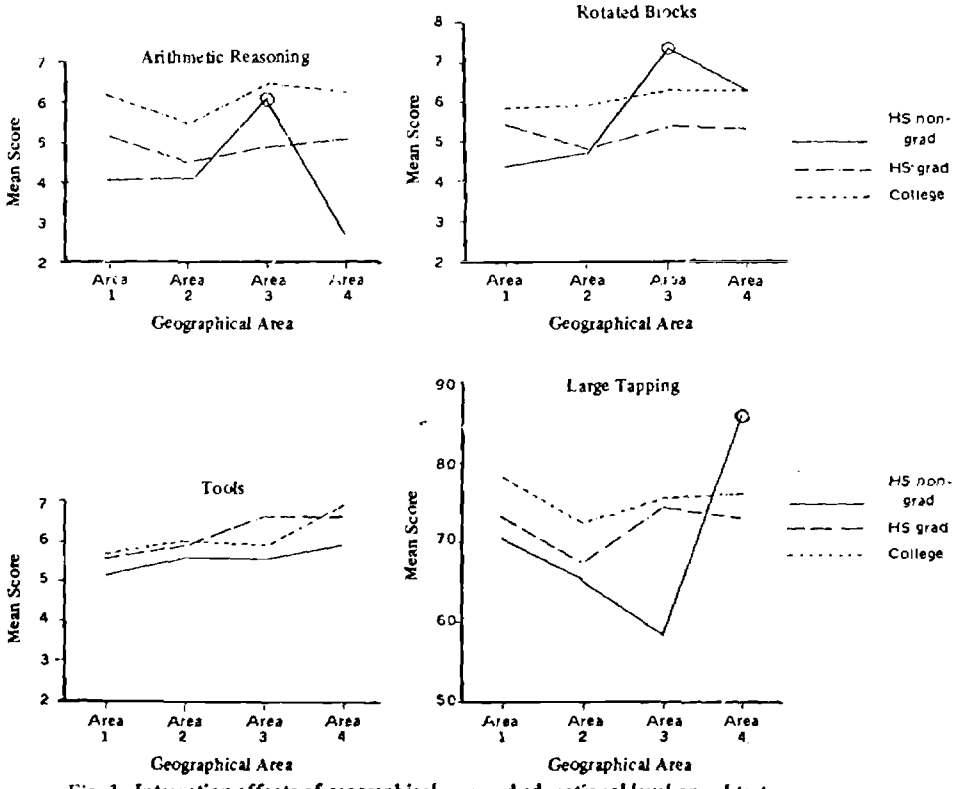

Fig. 3. Interaction effects of geographical area and educational level on subtest performance. *(Circled plots for Arithmetic Reasoning and Rotated Blocks subtests indicate mean based on less than 10 cases; for Large Tapping subtest, circled plot indicates mean based on 10 cases.)*

For the Figure Analogies and Object Completion tests, the significant race and area interaction as shown in Figure 2 indicates that differences in test performance between Negroes and whites were not the same in various parts of the United States. Although whites as a group obtained higher scores than Negroes across all areas on the Figure Analogies test, the differences were most evident in area 4 (Western subgroup). For Object Completion, the differences in test performance were greatest in area 2 (Southern regions) and area 4 (Western regions).

Figure 3 illustrates the differential effects of education with respect to area for the Arithmetic Reasoning, Tools, Rotated Blocks, and Large Tapping subtests. For three of the subtests (Arithmetic Reasoning, Rotated Blocks, and Large Tapping), the general trend in performance at the high school and college levels indicates that those with more education scored higher than those with less education. The number of cases in the nongraduate category was too small to permit interpretation. No consistent trend with respect to specific areas across subtests was noted.

For the remaining aptitude tests, no further analyses involving the interaction variables were considered necessary. The small number of interactions appears to indicate that the relationships between race, area, and education are not as complex and interrelated as previously anticipated.

Other regression analyses were performed for each aptitude test to determine the extent to which performance on that particular test varied with the cultural variables of race, geographical area, and educational level and the extent to which the variability associated with each one of the cultural variables was independent of the variability associated with the other cultural variables. These analyses were designed to answer questions such as "Do Negro enlistees differ in their test performance from white enlistees after educational level and area of the country are taken into account?"

The specific results of these analyses are summarized in Tables 4 and 5 and are presented in more detail in Tables 10 through 12 in the appendix. In the first column of Table 5 the squared multiple correlation coefficients between the demographic variables in combination and each aptitude test are listed. The relationships were all statistically significant, but the size of the relationships was quite low for several of the tests. Tests showing the strongest relationships with the demographic variables appeared to be those commonly thought of as the components of general intelligence—verbal, numerical, and reasoning factors. The weakest relationships were those tests of memory, spatial, and psychomotor factors.

Further examination of Tables 4 and 5 indicates that the variables of education, race, and area had significant net relationships with a majority of tests. Caution should be exercised in interpretation of the net relationships for those aptitude tests where a significant interaction was found. Race appeared to be related to tests in most factor areas although the highest relationships were found in the mechanical area. Education showed the highest relationships with the verbal, numerical, and reasoning factors and lowest relationships with the mechanical factor. No distinct trend was apparent between the relationships of geographical area and factor content.

Table 4. **Significance of Contribution of Primary Variables to Prediction of Subtest Performance**
(Summary of Regression Analysis Results)

Criterion Subtest	Significance Level of Primary Variable		
	Race	Education	Area
Answer Sheet Marking	.01	.01	.01
Arithmetic Reasoning	.01	.01	.01
Arithmetic Speeded Operations	.01	.01	.01
Block Counting	.01	.01	.01
Data Interpretation	.01	.01	.01
Electrical Information	.01	.01	.05
Electrical Maze	.01	.01	ns
Figure Analogies	.01	.01	.01
General Mechanics	.01	.01	.01
Hidden Figures	.01	.01	.01
Large Tapping	.01	.01	.01
Mechanical Principles	.01	.01	.01
Mutilated Words	.01	.01	.01
Number Series	.01	.01	.01
Number-Word	.01	.01	ns
Object Completion	.01	.01	.01
Pattern Comprehension	.01	.01	.01
Pattern-Detail	.01	.01	.05
Pursuit Aiming II	ns	ns	.01
Rotated Blocks	.01	.01	ns
Table Reading	.01	.01	.05
Tools	.01	.05	.01
Tool Functions	.01	ns	.01
Verbal Analogies	.01	.01	.01
Word Knowledge	.01	.01	.01

Table 5. Squared Multiple Correlation Coefficients of Combined[a,b] and Net Effects[c] of Predictor Variables

Criterion Subtest	R^2 for Predictor Variables			
	Variables Combined[a,b]	Race[c]	Educational Level[c]	Geographical Area[c]
Answer Sheet Marking	.0819	.0190	.0467	.0073
Arithmetic Reasoning[a]	.1506	.0542	.0628	.0074
Arithmetic Speeded Operations	.1475	.0338	.0940	.0159
Block Counting	.1349	.0736	.0310	.0098
Data Interpretation	.1251	.0513	.0539	.0076
Electrical Information	.0561	.0298	.0157	.0042
Electrical Maze	.0705	.0424	.0172	-
Figure Analogies[a]	.1764	.0397	.0854	.0236
General Mechanics	.1072	.0790	.0088	.0074
Hidden Figures	.0920	.0261	.0471	.0069
Large Tapping[a]	.0499	.0051	.0114	.0156
Mechanical Principles	.1229	.0792	.0175	.0077
Mutilated Words	.0889	.0270	.0386	.0109
Number Series	.1442	.0391	.0827	.0195
Number-Word	.0312	.0189	.0061	-
Object Completion[a]	.0665	.0148	.0271	.0073
Pattern Comprehension	.0677	.0213	.0322	.0076
Pattern-Detail	.0580	.0144	.0310	.0046
Pursuit Aiming II	.0100	-	-	.0068
Rotated Blocks[a]	.0721	.0266	.0239	-
Table Reading	.1544	.0601	.0753	.0036
Tools[a]	.0921	.0603	.0030	.0136
Tool Functions	.1062	.0537	-	.0349
Verbal Analogies	.1723	.0613	.0831	.0150
Word Knowledge	.1681	.0662	.0712	.0134

[a]For those tests with significant first order interactions, the combined R^2 contains the interaction variables as well as the primary variables.

[b]Contains primary variables of race, education, and area combined.

[c]Net effect indicates the independent contribution of the specific demographic variable in the context of the other variables.

Note: -- Dash indicates that the relationship between test performance and the demographic variable was not significant.

Figure 4 illustrates more clearly the actual differences in test performance between the demographic-cultural subgroups. Scores for each subgroup have been converted to standard scores to facilitate comparison across all aptitude tests. For instance, as shown in Figure 4, Negroes as a group scored lower than whites on all aptitude tests, especially those in the mechanical area. In general, their performance was more variable than white performance from test to test, and racial differences appeared smallest in the non-verbal, psychomotor, and memory areas. Although results from previous research have been far from conclusive in showing that Negroes or other persons from disadvantaged backgrounds do better on non-verbal or performance tests, the present results were consistent with findings which have demonstrated better performance by Negroes on tests of memory and perceptual speed and accuracy and poorer performance on tests of verbal and arithmetic reasoning (Shuey, 1966; Campbell, 1964; Woods & Toal, 1957).

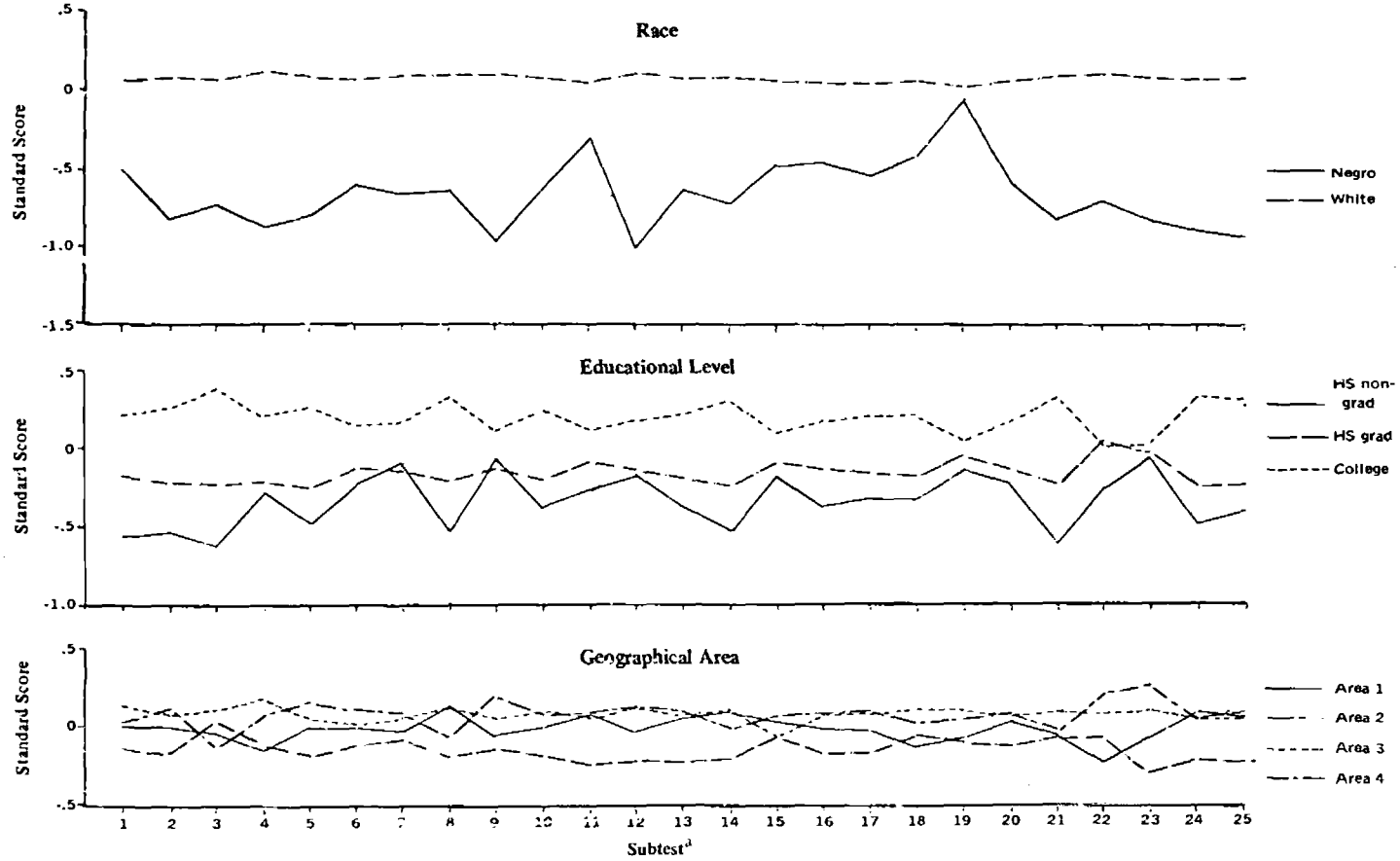

Fig. 4. **Comparative performance on aptitude subtests by race, educational level, and geographical area subgroups.**

[a]Numbers identify subtests as follows:

1. Answer Sheet Marking
2. Arithmetic Reasoning
3. Arithmetic Speeded Operations
4. Block Counting
5. Data Interpretation
6. Electrical Information
7. Electrical Maze
8. Figure Analogies
9. General Mechanics
10. Hidden Figures
11. Large Tapping
12. Mechanical Principles
13. Mutilated Words
14. Number Series
15. Number-Word
16. Object Completion
17. Pattern Comprehension
18. Pattern Detail
19. Pursuit Aiming II
20. Rotated Blocks
21. Table Reading
22. Tools
23. Tool Functions
24. Verbal Analogies
25. Word Knowledge

A comparison of performance of the educational subgroups tends to agree with previous findings from aptitude and educational data for Air Force enlistees (Vitola, Valentine, & Tupes, 1967). Those with more education displayed better performance, particularly in the verbal, numerical, and reasoning ability areas. Only in the mechanical area were reversals in performance noted; specifically, high school performance was better than college on the Tools aptitude test, and high school non-graduate performance surpassed high school graduate performance on the General Mechanics and Electrical Maze tests. Overall, more variability in test performance from test to test was found in the high school non-graduate group.

The differences in test performance between areas were not as distinct as those between races and educational levels. However, for a majority of tests, test performance of Area 2 (South) was lower than that for the other regions. These differences may be due in part to differences in the educational system throughout the United States. The results reflected a general trend found in previous Air Force studies in which airmen from the South have been found to score lower than airmen from other regions on selection and classification tests (Lecznar, 1965; McReynolds & Nichols, 1953).

Operational Implications for Screening Personnel

In order to illustrate more clearly the operational significance of the obtained subgroup differences in aptitude scores, another series of analyses were accomplished. These analyses show the percentages of each subgroup which would be rejected or selected if a certain selected cutoff score for each aptitude test were used to screen applicants. Table 13 in the appendix presents the results of these analyses.

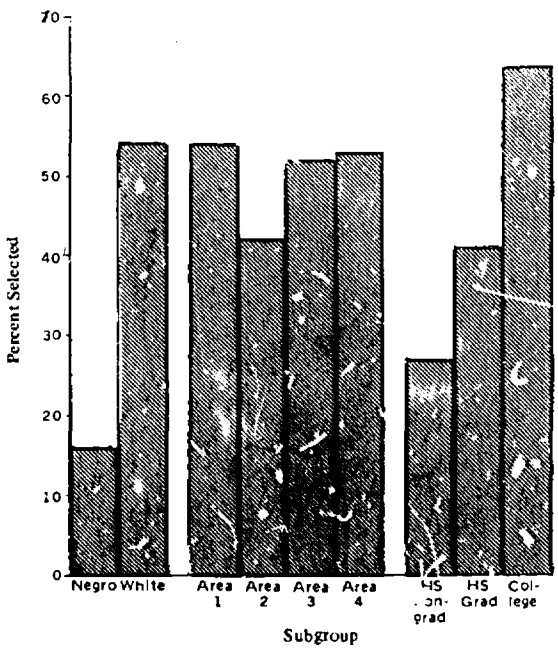

Fig. 5. Percentage of subgroup selected using mean Verbal Analogies score as cutoff.

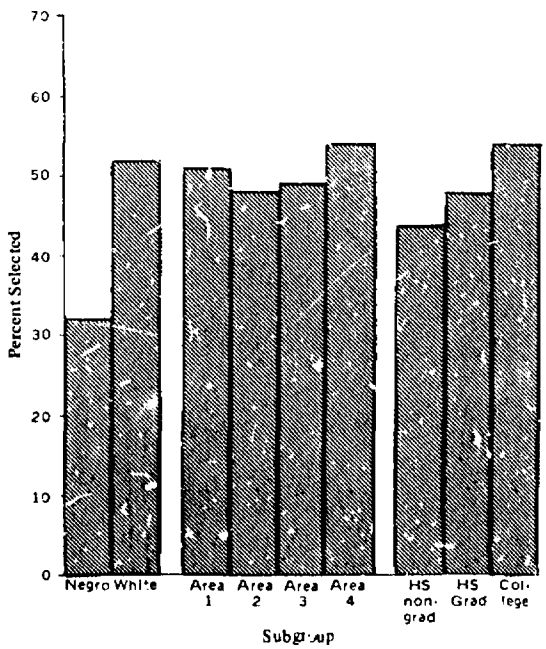

Fig. 6. Percentage of subgroup selected using mean Number-Word score as cutoff.

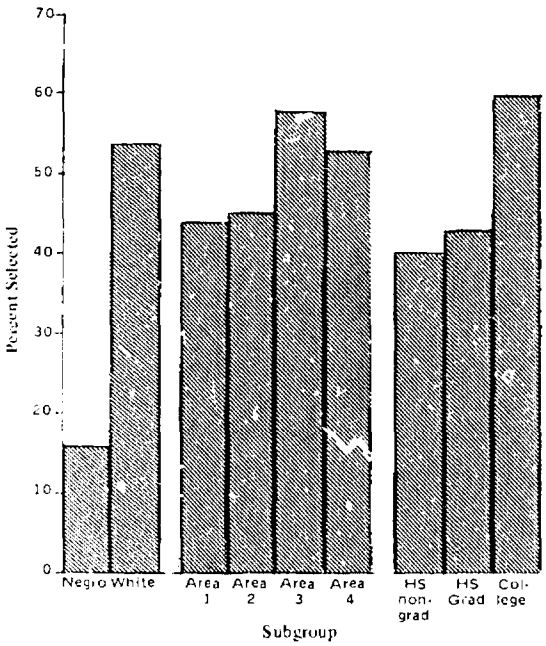

Fig. 7. Percentage of subgroup selected using mean Block Counting score as cutoff.

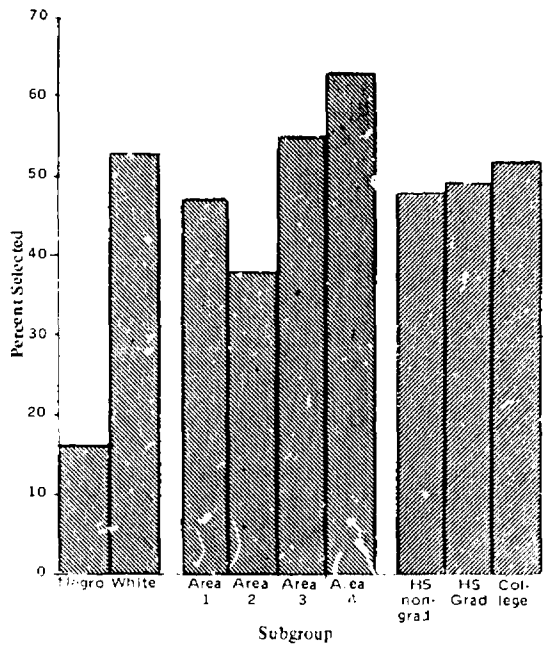

Fig. 8. Percentage of subgroup selected using mean Tool Functions score as cutoff.

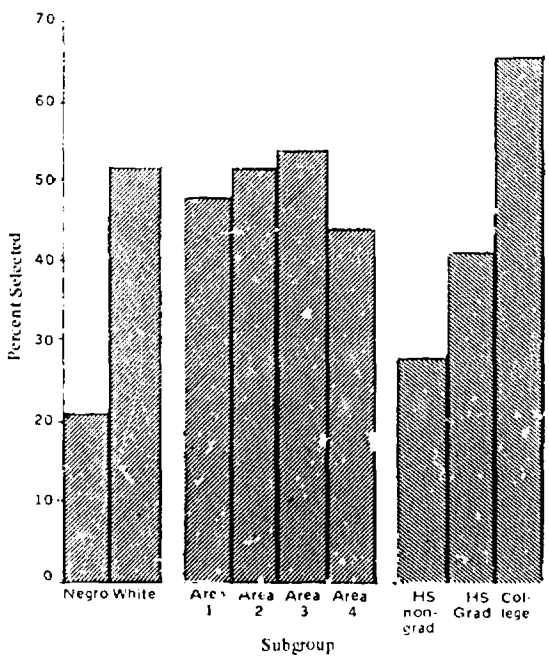

Fig. 9. Percentage of subgroup selected using mean Arithmetic Speeded Operations score as cutoff.

Figures 5 through 9 illustrate graphically for five aptitude tests the effects of screening upon the subgroups if the cutoff score were set at the test mean so that approximately 50 percent of the total group would be rejected and 50 percent accepted. In Figure 5, for example, it can be seen that if the test mean were used for screening, only slightly more than 16 percent of the Negro group would be considered acceptable whereas about 54 percent of the white group would be accepted. Similarly, the proportions selected from the other subgroups would be affected but to a lesser extent. Of interest is the differential effect of screening on the demographic subgroup for area; that is, screening on any one aptitude test may result in more than 50 percent of the subjects of a particular area being accepted whereas screening on another aptitude test may result in less than 50 percent of subjects from the same area being accepted.

IV. CONCLUSIONS

The fact that a significant interaction effect was found in six aptitude tests seems to indicate that higher order interactions of the cultural variables increase prediction over and above the contribution of the primary variables themselves, although the relationships between the primary variables may not be as complex and interrelated as was previously anticipated. The effects of the demographic variables combined were significant for all of the aptitude tests. For a majority of tests, the effect of the individual demographic variables of race, education, and area was also significant when the possibility of covariance with the other demographic variables was controlled.

It may also be concluded on the basis of these analyses that there are wide differences between aptitude tests in their sensitivity to demographic and cultural influences. There appears to be considerable interaction between the type (i.e., the factor content) of the test and the demographic variables with which its scores are most highly related. Educational differences are most highly related to performance on the tests comprising general intelligence (i.e., numerical, verbal, reasoning), while race differences have their highest relationships with mechanical type tests. This suggests that the typical finding that Negroes perform lower than whites on tests of general intelligence may be, in part, a function of differences in educational level and, further, that when education is held constant, such test differences are decreased. Differences in geographical area appear to be related to a variety of test types.

It should be noted that while the results of this study indicate that there are significant relationships between the demographic-cultural variables and aptitude test performance, the question of whether or not the lower-than-average test scores of the subgroup are indicative of equally low performance on later criteria of success has not been explored. Aptitude tests are designed to give an indication of an individual's potential for performing in a subsequent criterion or performance situation (e.g., in school or on the job). An aptitude test cannot be said to be biased or discriminatory unless the subgroup actually performs higher (or lower) in the criterion or performance situation than would be expected on the basis of its test scores. To answer this question adequately, further analyses of the interrelationships between test scores, demographic variables, and some measure of criterion performance should be carried out to determine whether each aptitude test actually discriminates against certain subgroups or whether subgroup differences in test scores are reflections of true differences in the underlying aptitude.

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APPENDIX

Table 6. Reliability Estimates and Factor Content of Aptitude Tests Comprising Five Test Batteries

Aptitude Test	Test-Retest Reliability	Factor Content
	Test Battery 1	
Color Form	.64	Perceptual Speed
Following Directions	.80	Attention, Verbal Comprehension, Numerical
Arithmetic Speeded Operations	.93	Numerical
Dot Estimation	.63	Decisiveness
Word Knowledge (Decision Making)	.76	Decisiveness
Stick and Rudder	.83	Spatial Orientation, Spatial
Aerial landmarks	.72	Perceptual Speed
Instrument Comprehension	.77	Spatial, Perceptual Speed, Visualization
Visualization of Maneuvers	.66	Visualization, Spatial
	Test Battery 2	
General Mechanics	.82	Mechanical Experience
Word Knowledge	.87	Verbal Comprehension
Data Interpretation	.56	Numerical, Deduction
Electrical Information	.88	Mechanical Experience, Verbal Comprehension
Number Series	.84	Numerical, Deduction, Verbal Comprehension
Pattern Comprehension	.77	Visualization, Deduction, Perceptual Speed
Tool Functions	.89	Mechanical Experience, Perceptual Speed
Verbal Analogies	.88	Verbal Comprehension, Deduction
General Science	.88	Verbal Comprehension
Arithmetic Reasoning	.88	Numerical, Deduction, Verbal Comprehension
Object Completion	.84	Gestalt Perception
Rotated Blocks	.79	Spatial, Spatial Orientation
	Test Battery 3	
Pattern Detail	.67	Associative Memory
Scale Reading	.78	Numerical, Spatial
Table Reading	.81	Numerical, Perceptual Speed, Spatial
Block Counting	.90	Spatial, Spatial Orientation, Perceptual Speed
Number Symbol Flexibility	.41	Numerical, Perceptual Speed
Answer Sheet Marking (Rights)	.84	Aiming, Perceptual Speed, Carefulness
Length Estimation	.69	Length Estimation
Electrical Maze	.80	Perceptual Speed, Planning, Spatial
Gestalt Transformation	.83	Deduction
Point Distance	.73	Length Estimation

Table 6 (*Continued*)

Aptitude Test	Test-Retest Reliability	Factor Content
	Test Battery 4	
Large Tapping	.85	Aiming, Tapping
Aiming	.70	Aiming
Pursuit Aiming I	.68	Aiming, Tapping
Pursuit Aiming ii	.76	Aiming
Square Checking	.50	Finger Dexterity
Tracing	.47	Aiming
Discrimination Reaction Time	.82	Reaction Time
Mechanical Principles	.86	Mechanical Experience, Visualization, Spatial
Hidden Figures	.81	Gestalt Flexibility, Spatial, Perceptual Speed
Physics	.88	Verbal Comprehension
Pattern Analysis	.51	Visualization, Perceptual Speed, Spatial
Number-Word	.78	Associative Memory
Mutilated Words	.69	Gestalt Perception, Spatial
	Test Battery 5	
Number Triangle	.76	Deduction, Induction
Tools	.91	Mechanical Experience
Word Grouping	.88	Verbal Comprehension, Perceptual Speed
Figure Analogies	.86	Planning, Deduction, Visualization
English Usage	.80	Verbal Comprehension
Letter Sets	.83	Induction
Number Reversal	.82	Perceptual Speed
Form Reasoning	.76	Deduction
Spelling	.86	Verbal Comprehension
Reading Comprehension	.83	Verbal Comprehension
Letter Counting	.56	Perceptual Speed
Number Size	.70	Perceptual Speed

[a]Factor content of aptitude tests based on analyses by French (1951) and authors' estimates of factor content for test areas not included in French analysis.

Table 7. Second Order Interaction Effects on Prediction of Subtest Performance

(Results of Regression Analyses)

Criterion Subtest	R^2 Full Model	R^2 Restricted Model	*df*	F
Answer Sheet Marking	.0877	.0870	6/1843	.26
Arithmetic Reasoning	.1513	.1506	4/1840	.37
Arithmetic Speeded Operations	.1594	.1563	5/1790	1.29
Block Counting	.1423	.1409	6/1843	.48
Data Interpretation	.1367	.1353	4/1840	.75
Electrical Information	.0666	.0630	4/1840	1.75
Electrical Maze	.0765	.0742	6/1843	78
Figure Analogies	.1785	.1764	6/1938	.83
General Mechanics	.1140	.1132	4/1840	.39
Hidden Figures	.1005	.0962	4/1824	2.20
Large Tapping	.0512	.0499	4/1824	.62
Mechanical Principles	.1256	.1250	4/1824	.83
Mutilated Words	.1001	.0958	4/1824	2.20
Number Series	.1515	.1502	4/1840	.67
Number-Word	.0365	.0358	4/1824	.34
Object Completion	.0682	.0665	4/1840	.82
Pattern Comprehension	.0752	.0724	4/1840	1.41
Pattern-Detail	.0653	.0639	6/1843	.48
Pursuit Aiming II	.0191	.0158	4/1824	1.52
Rotated Blocks	.0739	.0721	4/1840	.87
Table Reading	.1595	.1574	6/1843	.77
Tools	.0936	.0921	6/1938	.53
Tool Functions	.1056	.1062	4/1840	.23
Verbal Analogies	.1731	.1723	4/1840	.43
Word Knowledge	.1695	.1681	4/1840	.76

Table 8. First Order Interaction Effects on Prediction of Subtest Performance

(Results of Regression Analyses)

Criterion Subtest	R^2 Full Model	R^2 Restricted Model	*df*	F
Answer Sheet Marking	.0870	.0819	11/1849	.93
Arithmetic Reasoning	.1506	.1352	11/1844	3.03**
Arithmetic Speeded Operations	.1563	.1475	11/1795	1.70
Block Counting	.1409	.1349	11/1849	1.18
Data Interpretation	.1353	.1251	11/1844	1.97[a]
Electrical Information	.0630	.0561	11/1844	1.24
Electrical Maze	.0742	.0705	11/1849	.67
Figure Analogies	.1764	.1657	11/1944	2.30**
General Mechanics	.1132	.1072	11/1844	1.14
Hidden Figures	.0962	.0920	11/1828	.76
Large Tapping	.0499	.0370	11/1828	2.26**
Mechanical Principles	.1250	.1229	11/1828	.38
Mutilated Words	.0958	.0889	11/1828	1.26
Number Series	.1502	.1442	11/1844	1.18
Number-Word	.0358	.0312	11/1828	.78
Objection Completion	.0665	.0543	11/1844	2.20*
Pattern Comprehension	.0724	.0677	11/1844	.84
Pattern-Detail	.0639	.0580	11/1849	1.05
Pursuit Aiming II	.0158	.0100	11/1828	.98
Rotated Blocks	.0721	.0607	11/1844	2.06*
Table Reading	.1574	.1544	11/1849	.61
Tools	.0921	.0822	11/1944	1.93*
Tool Functions	.1062	.1009	11/1844	.98
Verbal Analogies	.1723	.1669	11/1844	1.11
Word Knowledge	.1681	.1612	11/1844	1.40

*Significant at .05 level

**Significant at .01 level

[a]Although the R^2 for the combined first order interaction effects reached the .05 level of significance, no individual first order interaction was found to be statistically significant. Therefore, this test was not included in the discussion of first order interactions.

Table 9. Specific First Order Interaction Effects on Prediction of Subtest Performance
(Results of Regression Analyses)

Criterion Subtest	R^2 Full Model	R^2 Restricted Model	d_f	F
	Race x Education			
Arithmetic Reasoning	.1506	.1462	2/1844	4.69**
Figure Analogies	.1764	.1736	2/1944	3.30*
Large Tapping	.0499	.0478	2/1828	.99
Object Completion	.0665	.0659	2/1844	.65
Rotated Blocks	.0721	.0698	2/1844	2.29
Tools	.0921	.0921	2/1944	.02
	Race x Area			
Arithmetic Reasoning	.1506	.1481	3/1844	1 82
Figure Analogies	.1764	.1719	3/1944	3.52*
Large Tapping	.0499	.0494	3/1828	.35
Object Completion	.0665	.0621	3/1844	2.94**
Rotated Blocks	.0721	.0707	3/1844	.94
Tools	.0921	.0894	3/1944	2.00
	Area x Education			
Arithmetic Reasoning	.1506	.1427	6/1844	2.84**
Figure Analogies	.1764	.1740	6/1944	.96
Large Tapping	.0499	.0402	6/1828	3.11**
Object Completion	.0665	.0605	6/1844	1.99
Rotated Blocks	.0721	.0698	6/1844	2.41*
Tools	.0921	.0848	6/1944	2.60*

*Significant at .05 level
**Significant at .01 level

Table 10. **Effects of Race on Prediction of Subtest Performance**
(Results of Regression Analyses)

Criterion Subtest	R^2 Full Model	R^2 Restricted Model	*df*	F
Answer Sheet Marking	.0819	.0629	1/1860	38.51**
Arithmetic Reasoning	.1352	.0810	1/1855	116.44**
Arithmetic Speeded Operations	.1475	.1137	1/1806	71.59**
Block Counting	.1349	.0613	1/1860	158.34**
Data Interpretation	.1251	.0738	1/1855	108.87**
Electrical Information	.0561	.0263	1/1855	58.64**
Electrical Maze	.0705	.0281	1/1860	84.67**
Figure Analogies	.1657	.1260	1/1955	93.04**
General Mechanics	.1072	.0282	1/1855	164.13**
Hidden Figures	.0920	.0659	1/1839	52.98**
Large Tapping	.0370	.0319	1/1839	9.61**
Mechanical Principles	.1229	.0437	1/1839	166.20**
Mutilated Words	.0889	.0619	1/1839	54.58**
Number Series	.1442	.1051	1/1855	84.76**
Number-Word	.0312	.0123	1/1839	35.94**
Object Completion	.0543	.0395	1/1855	29.06**
Pattern Comprehension	.0677	.0464	1/1855	42.35**
Pattern Detail	.0580	.0436	1/1860	28.34**
Pursuit Aiming II	.0100	.0100	1/1839	.08
Rotated Blocks	.0607	.0341	1/1855	52.55**
Table Reading	.1544	.0943	1/1860	132.02**
Tools	.0822	.0219	1/1955	128.42**
Tools Functions	.1009	.0472	1/1855	110.82**
Verbal Analogies	.1669	.1056	1/1855	136.56**
Word Knowledge	.1612	.0950	1/1855	146.44**

**Significant at .01 level

Table 11. **Effects of Educational Level on Prediction of Subtest Performance**
(Results of Regression Analyses)

Criterion Subtest	R^2 Full Model	R^2 Restricted Model	*df*	F
Answer Sheet Marking	.0819	.0552	2/1860	47.27**
Arithmetic Reasoning	.1352	.0724	2/1855	67.36**
Arithmetic Speeded Operations	.1475	.0535	2/1806	99.56**
Block Counting	.1349	.1039	2/1860	33.29**
Data Interpetation	.1251	.0712	2/1855	57.22**
Electrical Information	.0561	.0404	2/1855	15.46**
Electrical Maze	.0705	.0533	2/1860	17.18**
Figure Analogies	.1657	.0803	2/1955	100.08**
General Mechanics	.1072	.0984	2/1855	9.22**
Hidden Figures	.0920	.0449	2/1839	47.77**
Large Tapping	.0370	.0256	2/1839	10.89**
Mechanical Principles	.1229	.1054	2/1839	13.35**
Mutilated Words	.0889	.0503	2/1839	33.94**
Number Series	.1442	.0615	2/1855	89.71**
Number-Word	.0312	.0251	2/1839	5.77**
Object Completion	.0543	.0272	2/1855	26.54**
Pattern Comprehension	.0677	.0355	2/1855	32.05**
Pattern-Detail	.0580	.0270	2/1860	30.61**
Pursuit Aiming II	.0100	.0079	2/1839	1.97
Rotated Blocks	.0607	.0368	2/1855	23.63**
Table Reading	.1544	.0791	2/1860	82.78**
Tools	.0822	.0792	2/1955	3.18*
Tool Functions	.1009	.1009	2/1855	0.00
Verbal Analogies	.1669	.0838	2/1855	92.44**
Word Knowledge	.1612	.0900	2/1855	78.67**

*Significant at .05 level
**Significant at .01 level

Table 12. Effects of Geographical Area on Prediction of Subtest Performance
(Results of Regression Analyses)

Criterion Subtest	R^2 Full Model	R^2 Restricted Model	*df*	F
Answer Sheet Marking	.0819	.0746	3/1860	4.93**
Arithmetic Reasoning	.1352	.1278	3/1855	5.33**
Arithmetic Speeded Operations	.1475	.1316	3/1806	11.26**
Block Counting	.1349	.1251	3/1860	7.03**
Data Interpretation	.1251	.1175	3/1855	5.40**
Electrical Information	.0561	.0519	3/1855	2.75*
Electrical Maze	.0705	.0699	3/1860	.39
Figure Analogies	.1657	.1421	3/1955	18.39**
General Mechanics	.1072	.0998	3/1855	5.18**
Hidden Figures	.0920	.0851	3/1839	4.66**
Large Tapping	.0370	.0214	3/1839	9.94**
Mechanical Principles	.1229	.1152	3/1839	5.39**
Mutilated Words	.0889	.0780	3/1859	7.32**
Number Series	.1442	.1247	3/1855	14.08**
Number-Word	.0312	.0287	3/1839	1.59
Object Completion	.0543	.0470	3/1855	4.79**
Pattern Comprehension	.0677	.0601	3/1855	5.03**
Pattern-Detail	.0580	.0534	3/1860	3.01*
Pursuit Aiming II	.0100	.0032	3/1839	4.24**
Rotated Blocks	.0607	.0572	3/1855	2.27
Table Reading	.1544	.1508	3/1860	2.63*
Tools	.0822	.0686	3/1955	9.69**
Tool Functions	.1009	.0660	3/1855	24.00**
Verbal Analogies	.1669	.1519	3/1855	11.13**
Word Knowledge	.1612	.1478	3/1855	9.90**

*Significant at .05 level
**Significant at .01 level

Table 13. Percentage of Subgroups Selected Using Subtest Mean Score as Cutoff

Aptitude Subtest	Percentage of Subgroup Scoring Above Subtest Mean								
	Race		Geographical Area				Educational Level		
	Negro	White	Area 1	Area 2	Area 3	Area 4	HS Non-grad	HS Grad	College
Test Battery 1									
Color Form	23	52	46	46	55	55	41	44	60
Following Directions	28	52	46	48	56	50	41	44	59
Arithmetic Speeded Operations	21	52	48	52	54	44	28	41	66
Dot Estimation	37	51	44	48	53	55	46	48	54
Word Knowledge (Decision Making)	38	51	46	48	53	54	42	49	52
Stick and Rudder	17	52	43	46	56	55	32	45	59
Aerial Landmarks	24	52	47	44	54	56	34	46	58
Instrument Comprehension	19	52	46	46	52	55	32	44	60
Visualization of Maneuvers	15	52	46	45	55	54	33	42	63
Total N	139	1,674	410	532	477	394	74	1,071	668
Test Battery 2									
General Mechanics	9	54	48	44	52	57	48	46	56
Word Knowledge	17	54	53	42	53	54	34	41	63
Data Interpretation	19	53	50	43	52	56	31	42	62
Electrical Information	26	52	50	45	51	55	42	46	56
Number Series	18	53	54	42	54	50	27	41	63
Pattern Comprehension	22	52	50	44	54	54	36	44	58
Tool Functions	16	53	47	38	55	63	48	49	52
Verbal Analogies	16	54	54	42	52	53	27	41	64
General Science	27	52	49	47	52	53	30	40	65
Arithmetic Reasoning	16	53	50	43	53	54	28	42	62
Object Completion	30	52	50	44	53	54	34	45	58
Rotated Blocks	26	52	48	46	53	54	41	44	58
Total N	158	1,704	459	497	498	408	70	995	797
Test Battery 3									
Pattern Detail	32	52	45	48	55	51	35	44	59
Scale Reading	25	53	48	46	54	52	38	41	60
Table Reading	20	54	48	47	54	50	28	41	64
Block Counting	16	54	44	45	58	53	40	43	60
Number Symbol Flexibility	28	54	50	44	56	52	29	42	64
Answer Sheet Marking	30	52	50	44	56	50	31	44	60
Length Estimation	33	52	46	53	51	49	36	48	54
Electrical Maze	19	53	49	46	52	53	47	44	57
Gestalt Transformation	21	53	46	48	54	53	35	43	61
Point Distance	27	53	50	46	53	53	37	46	57
Total N	195	1,672	417	523	516	411	83	977	807

Table 13 (*Continued*)

Aptitude Subtest	Percentage of Subgroup Scoring Above Subtest Mean								
	Race		Geographical Area				Educational Level		
	Negro	White	Area 1	Area 2	Area 3	Area 4	HS Non-grad	HS Grad	College
Test Battery 4									
Large Tapping	40	51	53	39	52	54	43	46	55
Aiming	46	50	48	46	55	52	42	48	53
Pursuit Aiming I	38	51	48	46	56	52	34	47	55
Pursuit Aiming II	47	50	48	46	55	52	44	48	52
Square Checking	44	50	49	441	50	55	48	50	51
Tracing	44	50	50	47	54	50	47	50	50
Discrimination Reaction Time	24	53	48	44	51	56	36	44	58
Mechanical Principles	13	54	48	42	56	54	43	44	58
Hidden Figures	23	52	50	42	54	53	34	42	60
Physics	22	53	52	42	56	52	32	40	62
Pattern Analysis	22	53	52	43	54	52	41	45	57
Number-Word	32	52	51	47	48	54	44	47	54
Mutilated Words	26	52	52	41	53	54	37	43	60
Total N	159	1,687	453	460	423	510	63	971	812
Test Battery 5									
Number Triangle	28	53	56	43	54	48	32	44	63
Tools	21	54	41	47	54	59	40	51	50
Word Grouping	27	53	58	43	55	47	33	42	64
Figure Analogies	22	54	56	42	56	48	28	42	66
English Usage	26	53	57	48	50	47	26	41	66
Letter Sets	27	54	55	46	54	46	29	42	67
Number Reversal	26	54	55	47	52	48	35	42	65
Form Reasoning	27	54	54	45	52	49	33	44	63
Spelling	43	51	54	50	50	47	29	44	62
Reading Comprehension	23	54	54	45	54	49	28	40	67
Letter Counting	41	52	52	46	54	49	40	47	58
Number Size	27	54	57	45	53	46	33	44	62
Total N	237	1,725	436	571	505	450	134	1,060	768

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4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

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Nancy Guinn
Ernest Tupes
William E. Alley

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13. ABSTRACT

The joint and independent relationships between aptitude test performance and certain demographic-cultural variables were investigated as well as the relationships between these variables and the aptitude test factor content. Five test batteries were administered to groups of approximately 1,900 subjects each. Multiple linear regression analyses indicated that there were significant interaction effects for six of the selected tests. The relationship between the cultural variables combined and each aptitude test was significant for all tests. Significant net relationships of race, educational level, and geographical area were found with a majority of tests although wide differences were found among aptitude tests in their sensitivity to demographic-cultural influences. With regard to factor content, race appeared to be related to tests in most factor areas, with its highest relationship in the mechanical area. Education had the highest relationships with verbal, numerical, and reasoning factors and the lowest relationships with the mechanical area. No discernible trend with regard to factor content was noted for geographical area.

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